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EDITORIAL COMMENT

Crime Scene Investigation Approach to Sudden Cardiac Death*

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Sudden cardiac death (SCD) is a major public health problem in modern society. Despite tremendous advances in the medical sciences, it still defies our ability to identify subjects at risk. Nevertheless, a substantial core of knowledge has been gathered, and some principles have been established. One is the need for the concomitant presence of the triad of a structural-functional substrate, transient triggering factors, and arrhythmia mechanisms (1). Early epidemiological research using autopsy data allowed the identification of a significant list of structural substrates in the deceased, while imaging techniques identified both structural and functional substrates in those lucky enough to recover from SCD events. Coronary artery disease is the main cause of SCD, but in many cases, although the clinical history indicates that it is probably responsible for an SCD event, no autopsy confirmation can be obtained. This may be due to the precocity of the lethal arrhythmia, originating from the early histological modifications related to the acute ischemic injury. More recently, molecular substrates of genetic origin have been described in those presenting with SCD without any morphological or functional substrates (2), but a practical clinical application is lacking, mainly because of the expense.

See page 617

Autopsy has been a cornerstone in the development of medicine since the Renaissance. For many years, it was essential as part of a hospital's quality assurance program. In the last decades of the past century, a progressive decline in its use has been identified, with many explanations proposed: religious beliefs, low reimbursement, or simply discomfort of attending physicians to request authorization (3).

Meanwhile, a silent revolution was set in motion at forensic institutions worldwide using distinct definitions but with the same objectives. "Virtopsy" is a term coined by Thali et al. (4), in Bern, Switzerland, merging the terms "virtual" and "autopsy." In their definition, it was "meant to be an objective documentation and analysis process of physical features and evidence." In Japan, where the concept was developed earlier (in 1985), it is known as "autopsy imaging" and is widely available because of the large number of computed tomographic and magnetic resonance imaging (MRI) scanners available (5). A more generic term is "post-mortem imaging." An interesting experience took place in England, where a complete post-mortem MRI service was put in place by the local Jewish community; it is also used by Muslims and Christians in accordance with their religious orientation (6).

The initial main objective in most forensic services was to use post-mortem multidetector computed tomography and post-mortem MRI to elucidate forensic cases, traumatic or not. The 2 methods are complementary. The former is very helpful in the evaluation of bone fractures or lesions, in the detection of foreign bodies and gas, and in the identification and quantitation of coronary calcifications. The latter allows tissue characterization, a significant advantage in the noninvasive evaluation of solid organs. Particularly with MRI, many technical aspects must be adjusted to obtain interpretable images, such as considering the effect of body temperature at the moment of imaging acquisition (7). Also, common findings in the deceased, such as livor mortis and the coagulation of blood inside the vessels, must be taken into consideration to avoid misdiagnosis.

There is mounting evidence of post-mortem imaging's capability to explore the heart, especially with post-mortem MRI. All studies have used autopsy and histology as gold standards. Tissue characterization in T1-weighted and T2-weigthed images can clearly separate subacute, acute, and chronic myocardial infarctions (8). Post-mortem computed tomographic angiography and evaluation of the presence of chemical shift artifacts on T2-weighted images on post-mortem MRI are promising techniques to evaluate coronary artery patency (9). A recent review summarized the potential applications of this technique to investigate the most common causes of SCD, such as coronary artery disease and cardiomyopathies (10).

The pivotal study by Jackowski et al. (8) in this issue of the *Journal* contributes to the understanding of SCD related to coronary artery disease. In an unselected population referred to autopsy for clarification of the cause of death, the investigators elegantly demonstrate the existence of post-mortem MRI signs of peracute myocardial infarction in 53 of 76 patients with signs of myocardial involvement, a necessary substrate to complete the SCD mechanistic triad. A 3-T imaging system was used for the first time in cardiac post-mortem MRI, and it allowed higher resolution, with a possible relevant impact on the results. Image-oriented collection of histological samples

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confirmed early pathological modifications in a substantial percent of the cases. Also, a correlation with existing significant coronary stenosis related to the affected area was noted in 84.9% of subjects. The remaining 15.1% of the peracute areas presented with cocaine intoxication or severe myocardial hypertrophy, causes of myocardial ischemia without significant coronary obstruction. The study also reproduced previous findings from a small study from the same group relative to subacute and chronic infarctions (9). A timeline of imaging findings in the post-mortem MRI sequences seems to be well defined, but some aspects must be addressed. For instance, the time between an SCD event and imaging may affect the results or may require protocol adjustments. An important limitation was the absence of a control group, as acknowledged by the investigators, but the need for image-oriented sample collection as defined per protocol is a valid argument. A blinded sample analysis can be designed and included in a future protocol.

It is important to state that this new area is promising, and it may benefit from the existing decline in the use of autopsy if it proves to be as accurate as it is in other areas, such as trauma. There is a shortage of capable pathologists, radiologists, and imaging cardiologists trained to perform and read those exams. There is also a tremendous amount of data to be analyzed to establish some basic information, such as the differentiation of a previous existing blood clot and a clot developing post-mortem. We may eventually achieve a level of comfort in using post-mortem imaging as a diagnostic confirmation tool and as a quality assurance measurement in the near future. Another potential future benefit of this technique is the availability of minimally invasive, image-guided biopsies for histological and genetic investigation.

Post-mortem imaging is a new tool to explore SCD. As in popular television series, the careful collection and analysis of data from different sources, including clinical information and advanced post-mortem imaging, lead to the identification of the cause of death. From an epidemiological point of view, it will probably reduce the number of cases of unknown origin and may contribute to the establishment of a cost-effective diagnostic protocol.

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